

EMBRYONIC DEVELOPMENT TIME AND SPRING HATCHING OF THYRIDOPTERYX EPHEMERAIFORMIS

(LEPIDOPTERA: PSYCHIDAE)¹

R. D. Morden and G. P. Waldbauer²

Late in the winter after the eggs of the evergreen bagworm, *Thyridopteryx ephemeraeformis* (Haworth) have received sufficient chilling, the embryos begin development from their diapause stage. This can occur as early as January at the latitude of central Illinois. From this point until the eggs hatch, the developmental rate appears to be entirely determined by the amount of heat the eggs receive. Therefore, the time of hatching is variable depending upon temperature conditions each spring, as supported by four years of observations by Baerg (1928), who found the time of hatching in Arkansas to range from April 26 to June 1.

If the time of hatching were dependent on temperature, it would vary at different latitudes where the accumulated day degrees are different during embryonic development. At St. Louis, Missouri, the eggs were found to hatch from the middle to the end of May (Riley, 1869) i.e. later than in Arkansas. The time of hatching in Illinois varies from the latter part of May in the southern part of the state to the first part of June in the central region and the latter part of June in the north (English, 1965). Thus there does appear to be a gradient of hatching dates that is correlated with spring temperatures.

The bagworm is most susceptible to insecticides immediately after eclosion when the naked larvae begin to construct the bag which en-

¹Accepted for publication: May 17, 1971 [3.0109].

²Department of Entomology, University of Illinois, Urbana, IL 61801.

shrouds them during their larval life. Whether or not the bag affords an effective barrier to insecticides has yet to be determined, but it is at this time when the bagworm is most vulnerable to insecticides. The above data show the time of year in which eclosion occurs; however it cannot be used to predict the actual hatching time for a particular year.

The purpose of the experiment was to examine embryonic development during the spring and to learn the duration and rate at which larvae emerge from the bag. This information should help determine the time to apply insecticides for optimal bagworm control.

METHODS AND MATERIALS.—To determine the time of hatch in 1969 in Urbana, Illinois, 114 bags containing eggs were collected from a *Juniperus virginiana* tree. These were divided into three groups to determine if the amount of exposure to direct sunlight had an effect on eclosion. Eighty nine bags which had received varying amounts of sunlight and shade were placed in plastic tubes 10 cm long and stoppered at both ends by corks which had 1.3 cm holes drilled through the center. These holes were lightly filled with cotton to prevent larvae from escaping and to maintain temperature and moisture conditions within the tube similar to that outside. These tubes were placed in the shade to avoid overheating by sunlight. A second group of 15 bags were taken from the side of the tree that received sunlight nearly all day, and each bag was placed in a 200 ml disposable cup with nylon mesh ends. The containers were placed in the sun so that sunlight penetrating through the nylon mesh could reach the bags, and air currents could move in a vertical direction through the container. Thus the difference in temperature between the inside and outside of the container was negligible even though these containers were kept in the sun. Ten bags of a third group which had received little or no direct sunlight during the winter, were placed in 200 ml disposable cups with nylon mesh ends and these were placed in the shade.

Each day newly hatched larvae were removed from the tubes and the disposable cups. This made it possible to determine the span of time larvae emerged from the parent bag. Six bags from the group receiving varying amounts of sun and shade were placed in 19 × 65 mm glass vials and stoppered with a cotton plug. Each day hatched larvae were removed from these vials and counted. After hatching

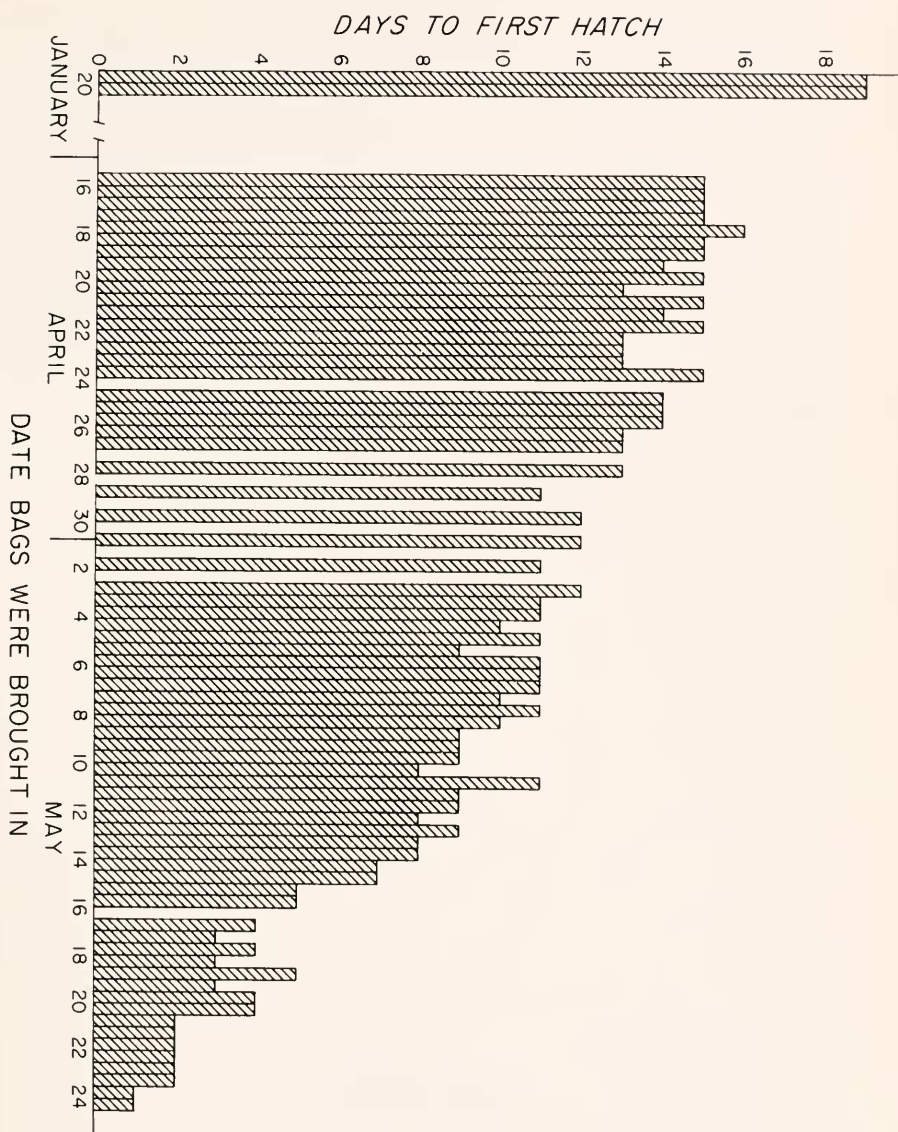


FIGURE 1. Days required for the first larvae to hatch from masses of bag-worm eggs brought in from the field to a constant temperature of 29°C on various dates in 1969. Two bags each represented by a single line were brought in each day. Spaces result from bags containing no eggs when later examined.

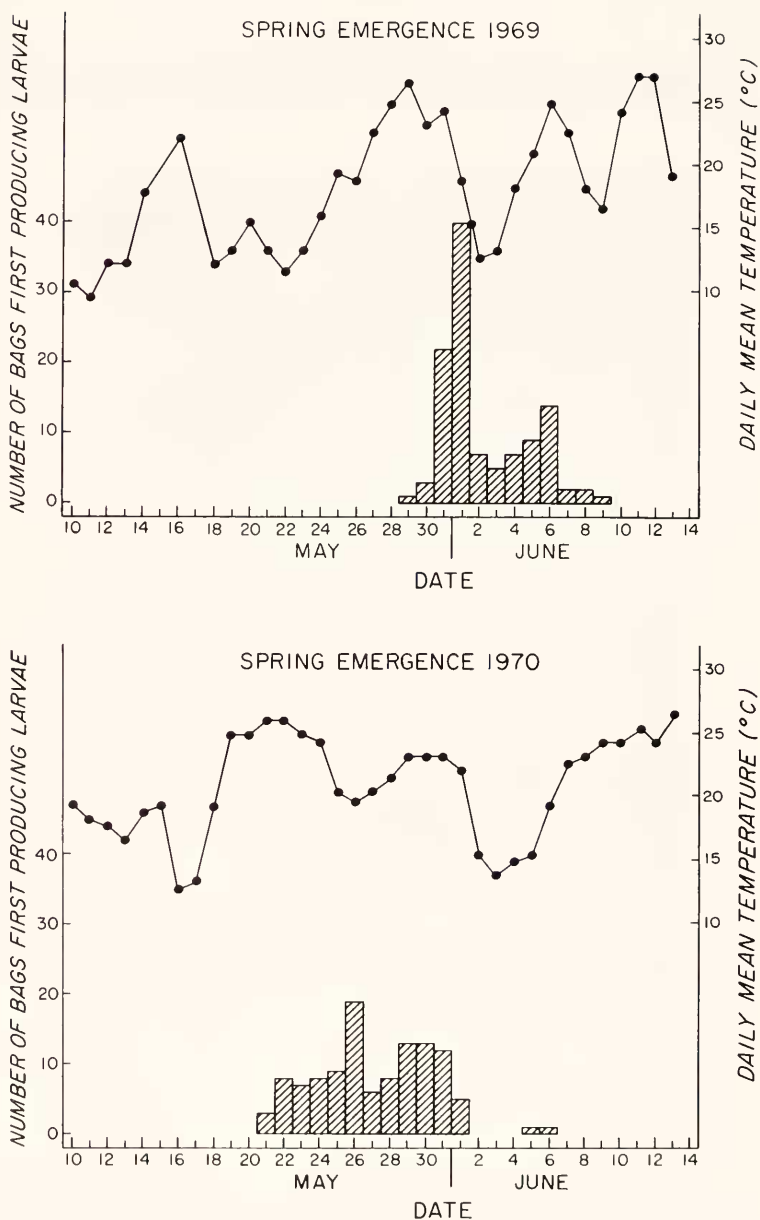


FIGURE 2. Histogram of spring hatching of *Thyridopteryx ephemeraeformis* in relation to graph of mean daily temperature during 1969 and 1970.

was completed, unhatched eggs in each vial were counted to determine percent eclosion. During the following season (1970) only the first emergences were recorded.

RESULTS.—Embryonic development of bagworm eggs progressed until June 9 with the first larvae appearing May 25 (Fig. 1). If May 25 is taken as the culmination of embryonic development then this was 25% complete around April 21, 50% complete about May 10, 75% complete around May 17 and 100% complete by May 25. As environmental temperatures increased during the spring the rate of development accelerated.

The time range in emergence of the first larvae from bags was from May 29 to June 9 in 1969 and from May 21 to June 6 in 1970 (Fig. 2). The departure from the mean temperature during May 1969 was $+1.1^{\circ}\text{C}$ while the departure from the mean during May 1970 was $+2.4^{\circ}\text{C}$. The range of time between the first and last emergence of larvae during 1969 was from May 29 to June 14. When temperatures are high larval eclosion is greater than when temperatures are low. Gromysz (1960) found with *Psyche viciella* that the temperature at which activity ceases was 18°C . This is in close agreement with our observations for *T. ephemeraeformis*. During spring eclosion, 1970, on two days the temperature failed to exceed 18°C , and no bags produced larvae on those days.

Bags kept totally in the sun start to produce larvae before those which experienced both sun and shade (Fig. 3). The bags which experienced total shade were among the last from which larvae emerged. The earlier a bag starts to produce larvae, the longer it takes for the hatch to be complete—generally from 8 to 10 days. Conversely the later the bag starts to produce larvae, the shorter the duration of egg hatch with completion occurring in 4 to 8 days.

Eggs in bags experiencing both sun and shade during the winter take eight days to complete eclosion (Fig. 4). It was found that 15% of the eggs hatched by the third day, 82% of the fifth day and 89% by the eighth day. The remaining 11% of the eggs failed to produce larvae.

DISCUSSION.—There is evidence from a diapause termination experiment conducted in this laboratory that when diapause is completed under conditions of chilling which prevent embryonic development, it takes eighteen days at 29°C for the eggs to complete em-

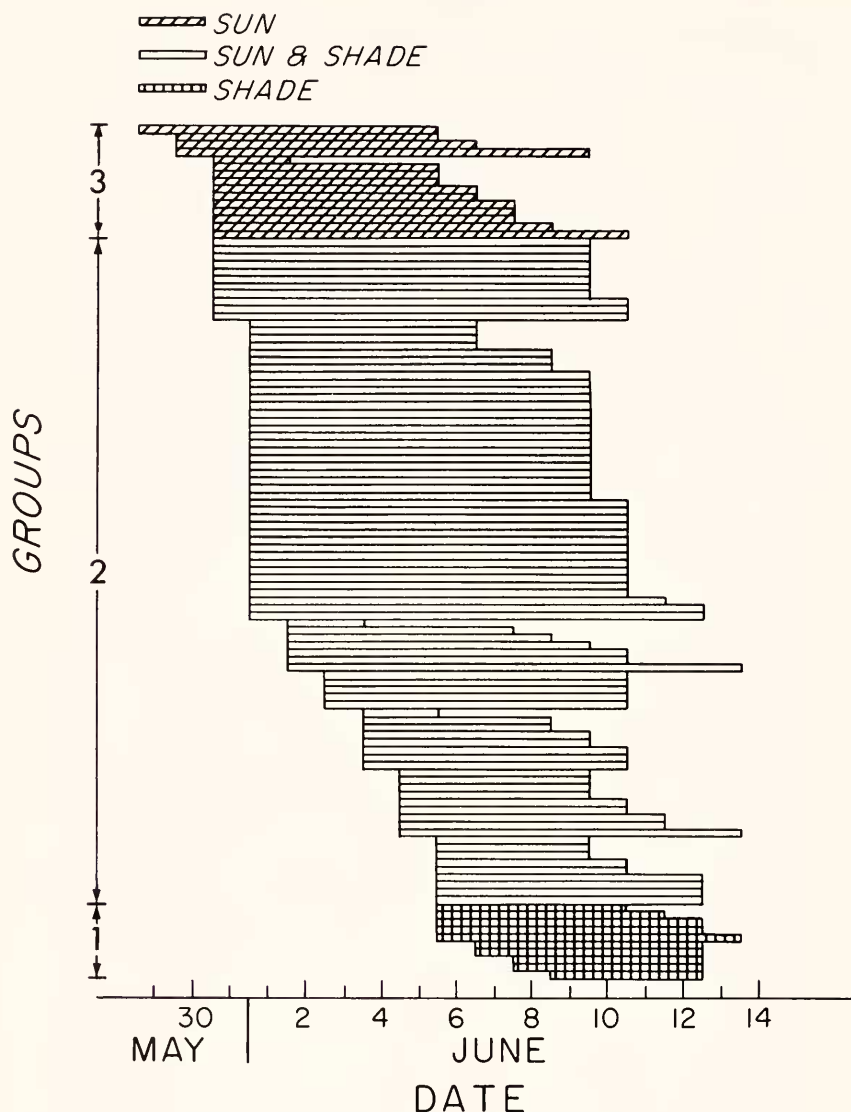


FIGURE 3. Duration of hatching period of individual bags ranked according to earliest hatch, with each line representing an individual bag. See text for complete explanation of figure.

bryonic development (Morden and Waldbauer, in press). Diapause is essentially completed by the last part of January at the latitude of

Urbana, Illinois. At this time it is possible for daytime temperatures to be warm enough for embryonic development. Though embryos may develop during this period, they are still cold-hardy, for they survive many days below freezing. In the area of Urbana most of the embryonic development occurs during May. The average temperature during this month was 1.3°C higher in 1970 than in 1969, and as expected, the hatch occurred earlier in 1970.

The importance of temperature is demonstrated further since during the hatching period bags which experienced direct sunlight during the day took longer to complete their hatch than bags experiencing no direct sunlight. Since photoperiod has no effect on egg hatching (Morden and Waldbauer, in press) the difference apparently results from heating by direct sunlight.

For male and female bagworm adults to emerge in synchrony and mate successfully before the temperature becomes too cold for this

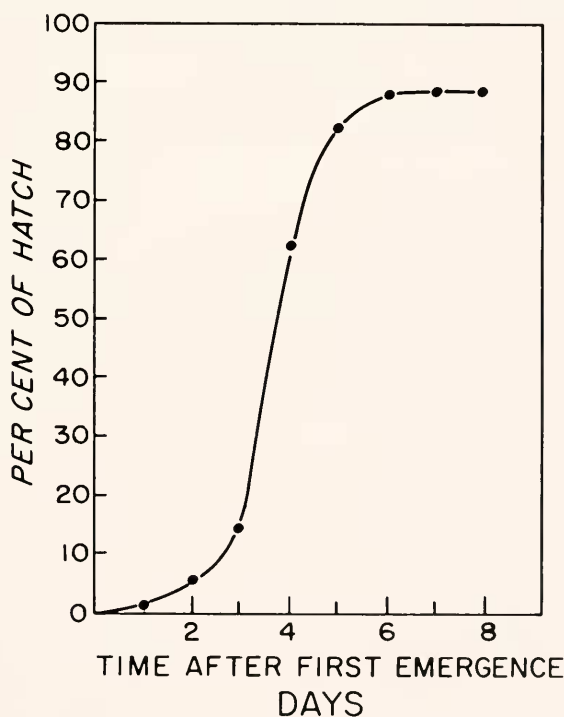


FIGURE 4. Rate of hatch of field population during 1969.

activity, it is essential their development be synchronized. Since they apparently have no mechanism for coordinating the population development by use of photoperiod, and since they seem to respond only to environmental temperatures, they must therefore start their larval life at approximately the same time. The data shows that the range of larval emergence is approximately two weeks. If it took any longer, the chance of successful mating in the fall for the lagging portion of the population would be greatly diminished for the temperature rapidly falls below that needed for activity.

Mortality of the eggs in the six vials hatching in the spring was 11% which is in excellent agreement with results obtained in this laboratory in a diapause termination experiment (Morden and Waldbauer, in press).

It should be possible to provide maximum control of bagworms using insecticides by monitoring embryonic development and spring temperature conditions and knowing the duration and rate of hatch.

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2.0109 Embryonic development time and spring hatching of *Thyridopteryx ephemeraeformis* (Lepidoptera: Psychidae).

ABSTRACT.—Embryonic development of *Thyridopteryx ephemeraeformis* (Haworth) proceeds from January to June at the latitude of central Illinois with most of the development occurring during May. Spring hatching lasts for about two weeks with the greatest number emerging near the middle of this period.

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Descriptors: Lepidoptera; Psychidae; *Thyridopteryx ephemeraeformis*, embryonic development, hatching time; bagworm; embryonic development time; hatching, spring.

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Between 1910 and 1920 Arthur Loveridge was official naturalist, game warden, collector and writer in East Africa. He retired from East Africa to become curator of reptiles and amphibians of the Harvard University museum, a chair he occupied for 35 years. He frequently revisited East Africa and there is little doubt that he has been its foremost naturalist. While holding his American post for these 35 years he never became an American citizen. He is the author of a great many papers on natural history.

Today at almost 80 Arthur Loveridge lives a quiet life at Varneys, Island of Saint Helena, South Atlantic Ocean. It was here that Napoleon Bonaparte was exiled from France from 1815 to 1821. On occasion when feeling a change necessary Mr. Loveridge journeys north and visits with British naturalists in his native country of England. While at home his correspondence to fellow naturalists the world over must be great for the letter from which the above quotes were made bears Mr. Loveridge's file number 4,855.

Descriptors: Hymenoptera; Isoptera; Siphonoptera; Dermoptera; bats; gerbils; Africa, insects and mammals; Saint Helena Island; Arthur Loveridge.